

***Smart Charging of Plug-in Vehicles and Driver  
Engagement for Demand Management and  
Participation in Electricity Markets  
Agreement #EPC-14-057***

**Fourth Annual California Multi-Agency Update  
on Vehicle-Grid Integration Research**

**December 5, 2017**

# Project Overview

- Alameda County (AlCo) objectives:
  - Offer low-cost charging to the public to encourage EV use
  - Convert fleet vehicles from ICEs to EVs to meet environmental goals
  - Aim to reduce costs, particularly demand charges for both fleet and privately-owned EVs that use AlCo charging stations
- Project goal is to create an automated smart charging control system to minimize electricity costs related to fleet and public EV charging



# AlCo Park Garage—Primary public and fleet charging location

- Total Ports: 14 Level 1 and 36 Level 2



5 CT2100 each with a L1 and L2 port

5 CT2100 each with a L1 and L2 port  
3 CT4020 each with two L2 ports



1 CPE200 DCFC with 1 SAE Combo and 1 CHAdeMO

4 CT2100 each with a L1 and L2 port  
8 CT4020 each with two L2 ports

## Floor 8

Public Access  
7a-7p  
Fleet Charging  
7p-7a

## Floor 2

Public Access  
7a-7p  
Fleet Charging  
7p-7a

**Street Level**  
24-h Access

## Basement

Fleet Operations;  
No public access

# Alameda County—PEVs and PHEVs at AlCo Park Garage



**12** Nissan LEAF  
24 kWh battery



**2** Chevy Bolt  
60 kWh battery



**17** Ford Focus Electric  
23 kWh battery



**2** Toyota RAV4 EV  
41.8 kWh battery



**2** Toyota Prius Plug-in  
4.4 kWh battery

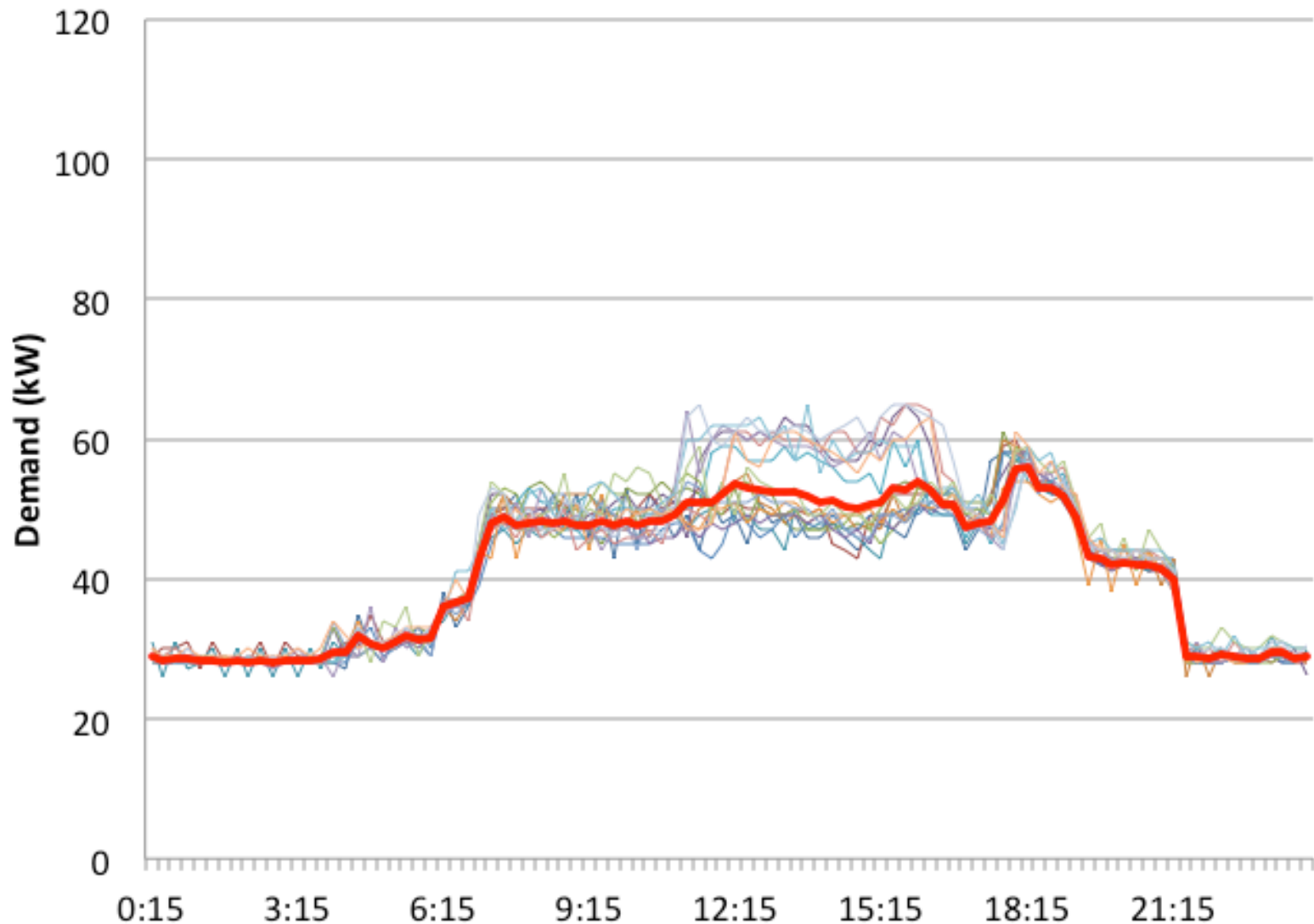


**2** Chevrolet Volt  
16.5 kWh battery

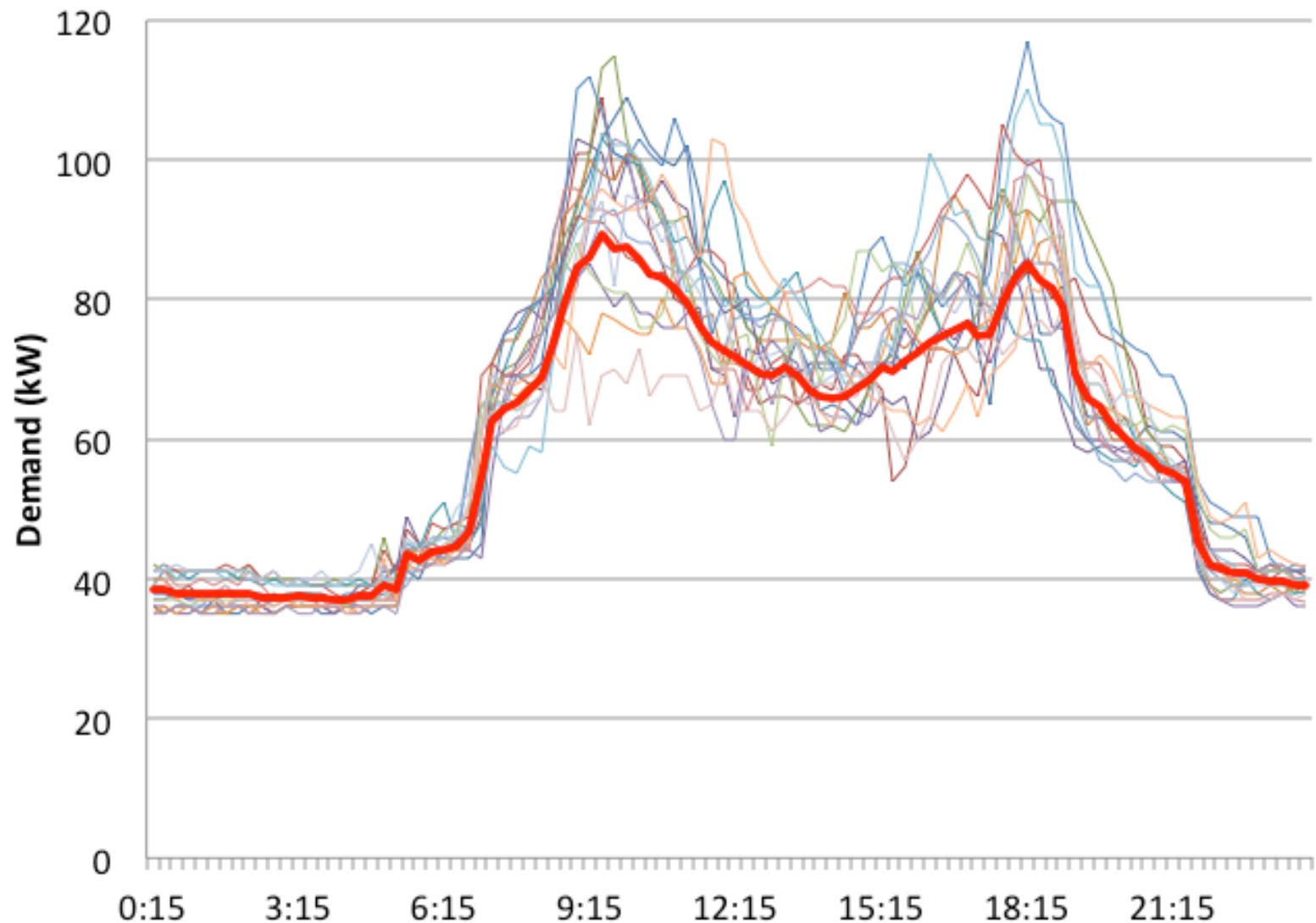


**3** Ford C-Max Energi  
7.6 kWh battery

# AlCo Park Weekday 15-min Demand Feb 2013

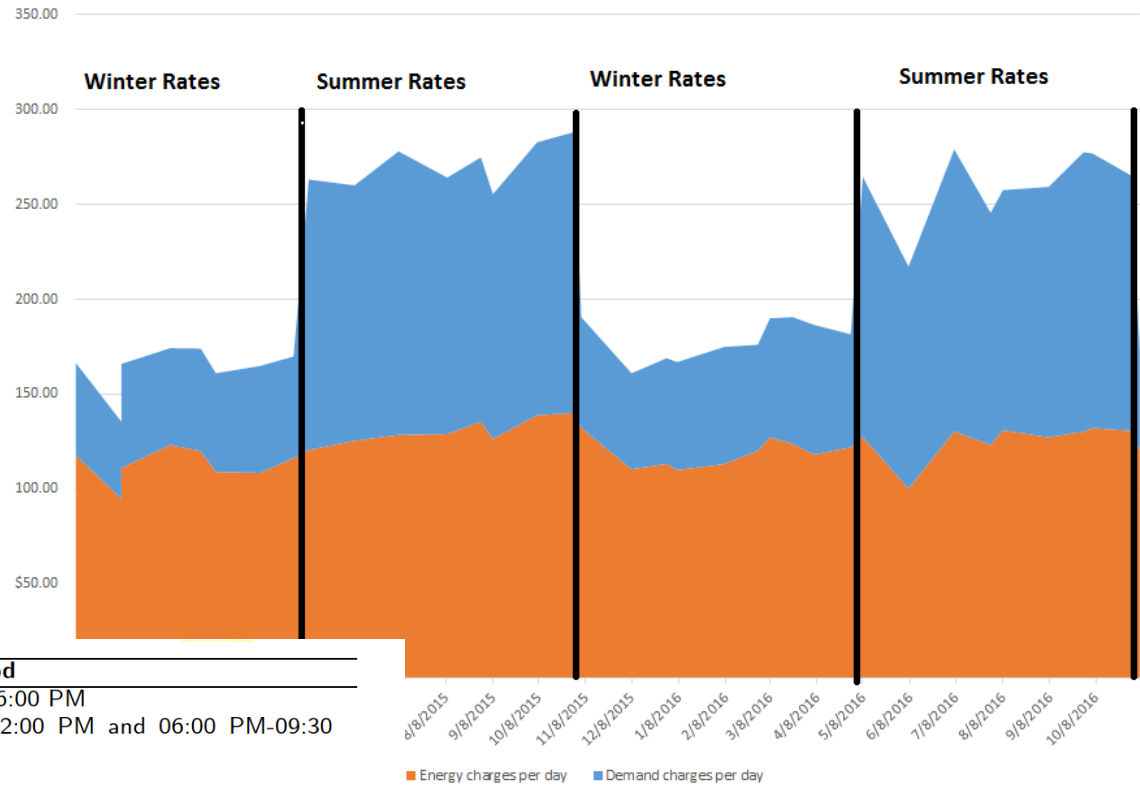


# AlCo Park Weekday 15-min Demand Feb 2015



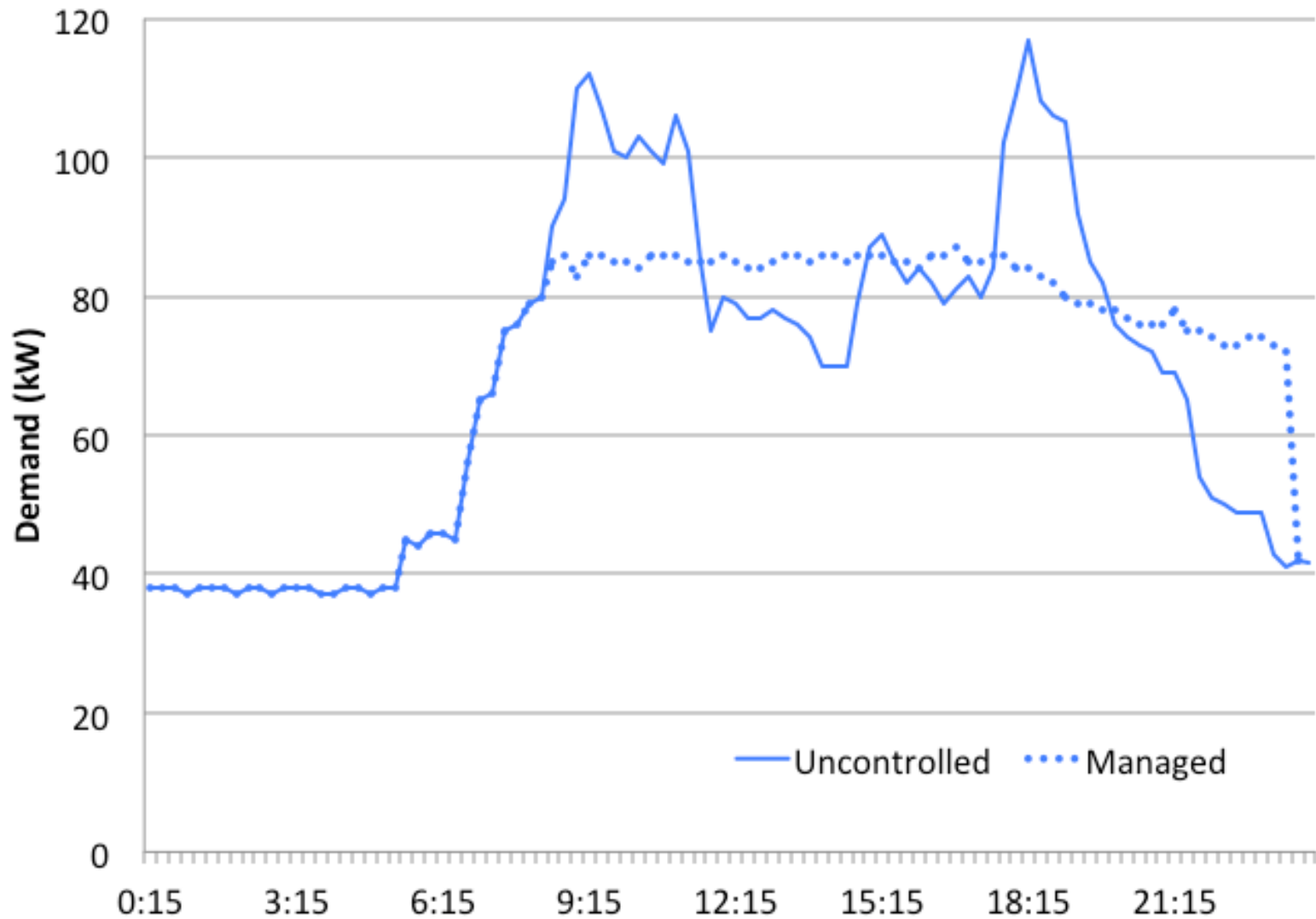
# Electricity costs

Demand Charges and Energy Charges per Day



Demand Charges	\$/kW	Time period
Max. peak demand summer	\$18.74	12:00 PM-6:00 PM
Max. part-peak demand summer	\$5.23	8:30 AM-12:00 PM and 06:00 PM-09:30 PM
Max. demand summer	\$17.33	Any time
Max. part-peak demand winter	\$0.13	8:30 AM-09:30 PM
Max. demand winter	\$17.33	Any time
Energy Charges	\$/kWh	Time period
Peak summer	\$0.14726	12:00 PM-6:00 PM
Part-peak summer	\$0.10714	8:30 AM-12:00 PM and 06:00 PM-09:30 PM
Off-peak summer	\$0.08057	Any time
Part-peak winter	\$0.10166	8:30 AM-09:30 PM
Off-peak winter	\$0.08717	Any time

# Goal is to cut off demand peaks



# Approach for Fleet EV Smart Charging

- Shift charging to times with lower electricity costs
  - Stagger to minimize anytime peak charge
  - Immediately charge minimum number of vehicles needed for later day trips or to work with fleet staff operating hours and need for rotating EVs among charging stations
- Key Variables
  - Vehicle use-factor (fraction of vehicles that make trips per day)
  - Total number of EVs compared to total number of charging stations; “Rotating” EVs among charging stations presents challenge
  - Number of EVs that make trips each day to EVSE ratio
  - Charging station charge rate (1.6 kW, 6.6 kW, and 50 kW)

# AlCo Park Garage Charging Station Dashboard

Station Name	Vehicle	Load	Status	Demand Reduction Schedule	Action
<b>AlcoBase CT4000</b>					
ALCOBASE4000-1, Port 1	N/A	0	AVAILABLE	08:30:00 - 23:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-1, Port 2	N/A	0	AVAILABLE	08:30:00 - 01:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-2, Port 1	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-2, Port 2	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-3, Port 1	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-3, Port 2	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-4, Port 1	3330 Leaf 2016	5.971	INUSE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-4, Port 2	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-5, Port 1	N/A	0	AVAILABLE	08:30:00 - 21:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-5, Port 2	N/A	0	INUSE	08:30:00 - 03:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-6, Port 1	N/A	0	AVAILABLE	08:30:00 - 03:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-6, Port 2	N/A	0	AVAILABLE	08:30:00 - 21:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-7, Port 1	N/A	0	AVAILABLE	08:30:00 - 23:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-7, Port 2	N/A	0	AVAILABLE	08:30:00 - 01:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-8, Port 1	Fleet Master	0	INUSE	08:30:00 - 23:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE4000-8, Port 2	N/A	0	AVAILABLE	08:30:00 - 01:30:00	Defer Now <b>Sched</b> <a href="#">Detail</a>
<b>AlcoPark Basement</b>					
ALCOBASE - 001, Port 1	N/A	0	UNREACHABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE - 001, Port 2	2943 Focus Pool 20 Silver 2012	5.881	INUSE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE - 002, Port 1	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE - 002, Port 2	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE - 003, Port 1	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE - 003, Port 2	N/A	5.984	INUSE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE - 004, Port 1	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
ALCOBASE - 004, Port 2	3199 Focus EV pool 20	5.904	INUSE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>
<b>Alco DC Fast</b>					
FAST CHARGER, Port 1	N/A	0	AVAILABLE	None	Defer Now <b>Sched</b> <a href="#">Detail</a>

- Can schedule/pause charging or over-ride scheduling at any station
- Color-coding of charge status: green rows indicate fully charged

# Dashboard detail

## Alameda Dashboard

### Detail Screen

Select time frame for Demand Reduction:

**Start:**

**End:**

Update Schedule

Current Demand Reduction Schedule:

**08:30 AM - 09:30 PM**

Delete Schedule

#### Station Data

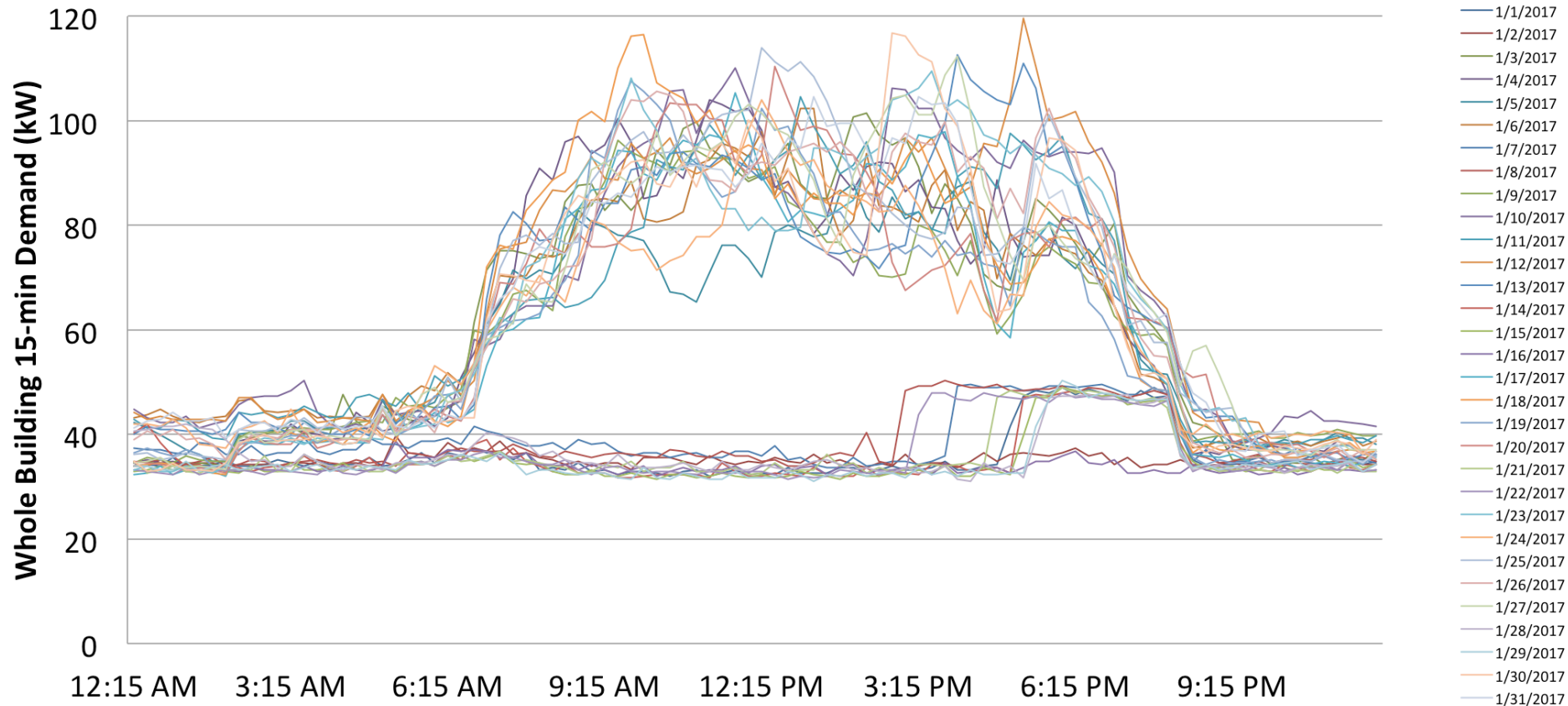
Station:	ALCOGARSTATIONS / ALCOBASE4000-6
Station ID:	1:122395
Serial:	151541001644
MAC:	0024:B100:0002:24FD
Manufacturer:	ChargePoint
Model:	CT4020-HD

#### Port Data

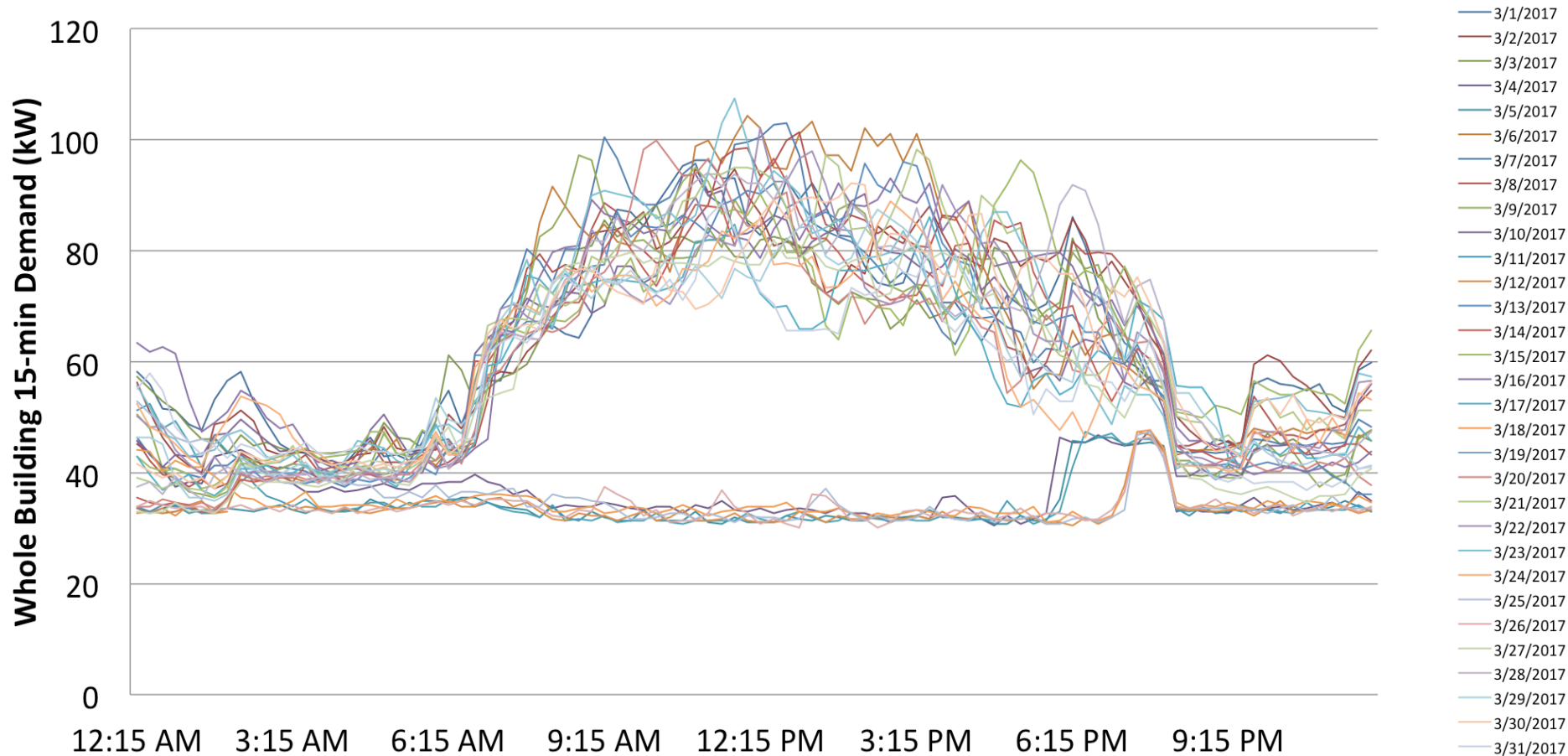
Port Number:	2	Current Load:	0.0
Level:	L2	Charging Status:	INUSE
Connector:	J1772	Credential ID:	CNS000286808
Voltage:	240V	Shed State:	0
Current:	30A	Allowed Load:	0.0
Max Power:	6.6kW	Percent Shed:	0

- Allows user to set demand reduction schedule
- During the demand reduction schedule, vehicle will not charge unless overridden

# January 2017 AlCoPark Garage Demand (kW)

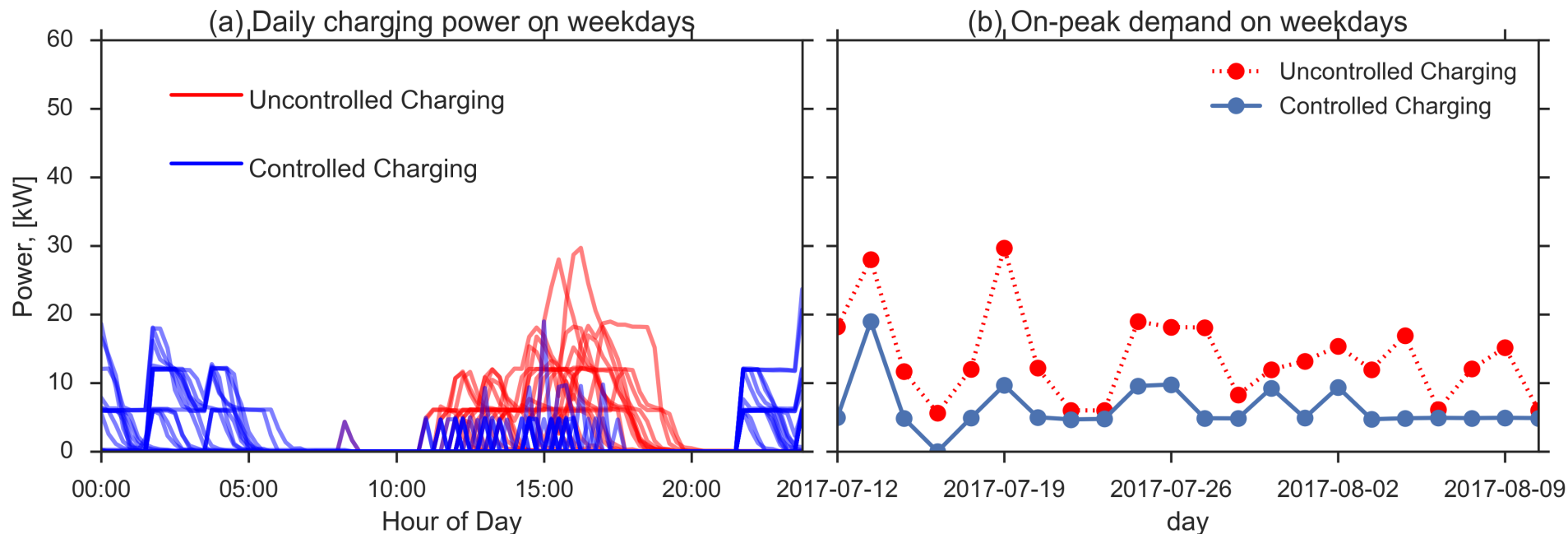


# March 2017 AlCoPark Garage Demand (kW)



# Fleet Charging Demand Reduction July 2017

- On-peak demand reduced by 10.7 kW
- Mid-peak demand reduced by 13.3 kW.

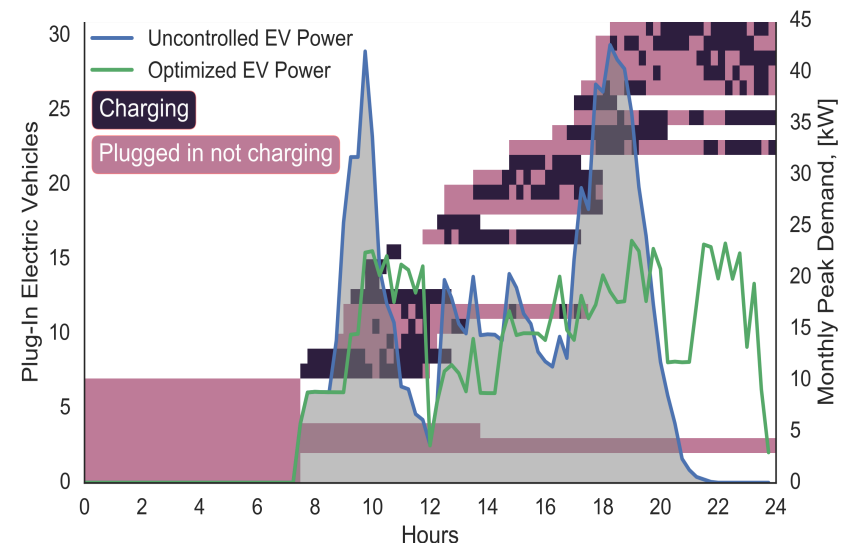
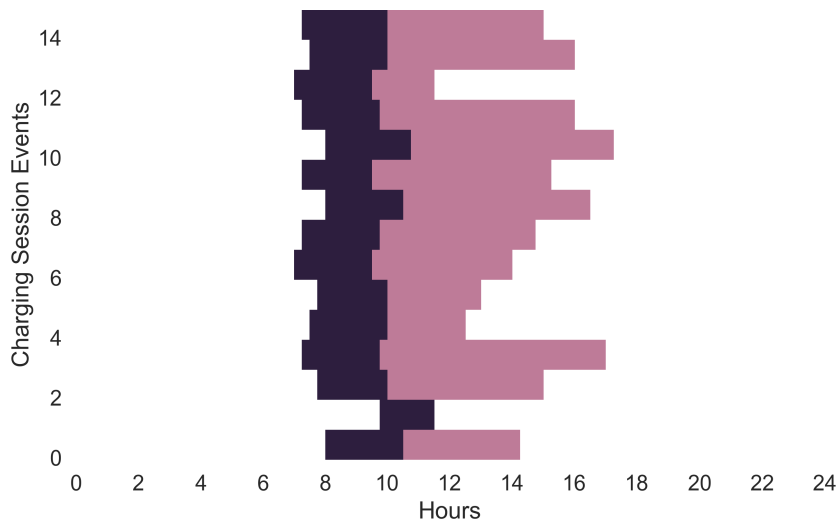


# Fleet Charging Summary

- Greater number of fleet PEVs than fleet EVSEs limits cost-saving potential from smart charging
  - Fleet staff can't rotate vehicles to available EVSEs outside of operating hours (7a-7p)
- Linking fleet vehicle trip management with smart charging control would improve performance, i.e. lower utility costs
  - Fleet staff concerned about disrupting long-standing system operations, i.e. change is hard
  - Working with AICo to more fully utilize fleet PEV dashboard

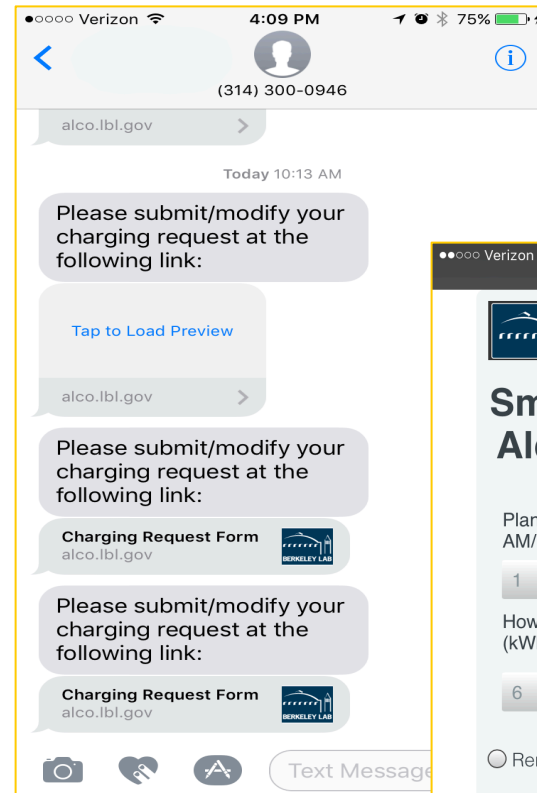
# Approach for Public EV Smart Charging

- Flexibility to shift charging is constrained to operating hours 7 AM to 7 PM (unlike fleet that can charge 24 h)
  - Peak period is 12p-6p so shifting out of peak is limited
- “Smooth” mid- and on-peak period demand
- Minimize risk to public charging station users by delivering charge energy equal to that of unmanaged charging



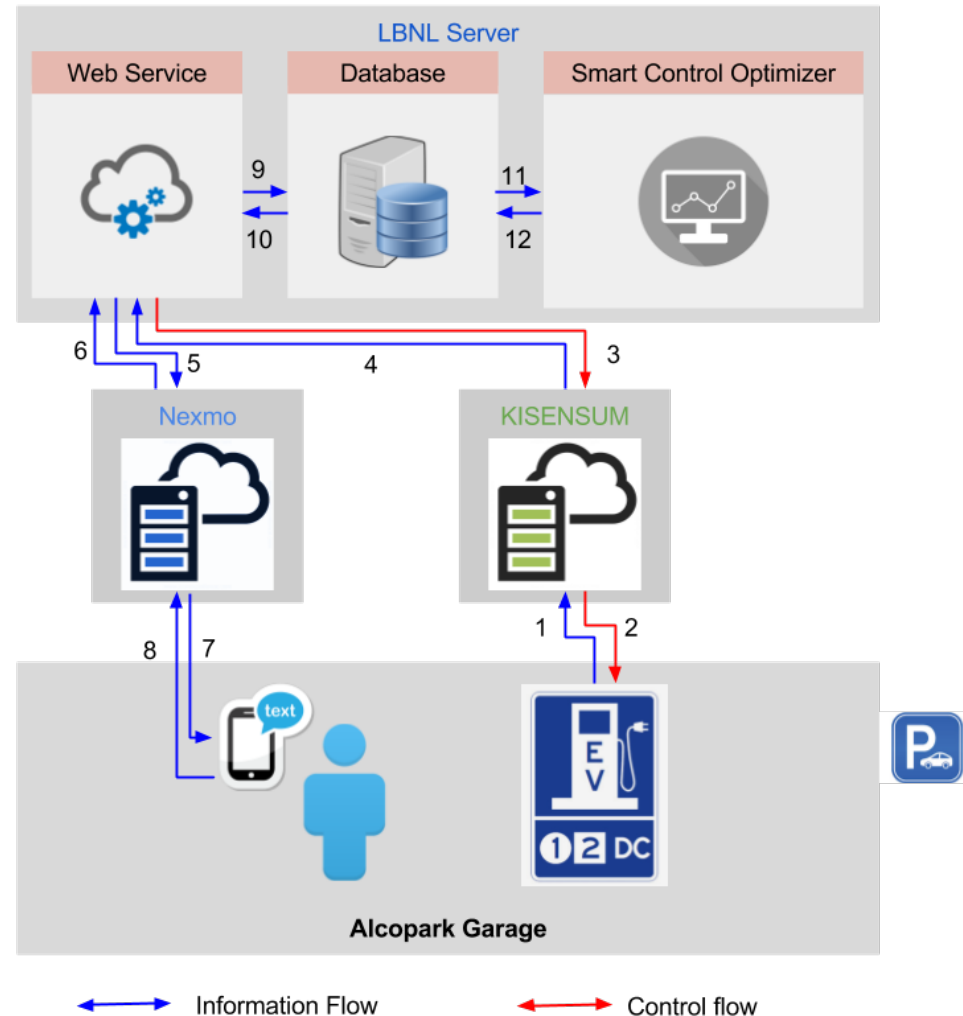
# Smart Control of Public Charging Stations

- Smart Charging participant starts a session at an AlCoPark charging station and receives a text with a link to web-site that requests estimated departure time and charge needed.
- Charging optimization code uses the user provided information along with current demand of all other AlCoPark charging sessions, and forecast of non-charging demand to create charging plans for all Smart Charging participants.
- User can change departure time and/or charge needed and charge plans will be re-optimized and implemented.

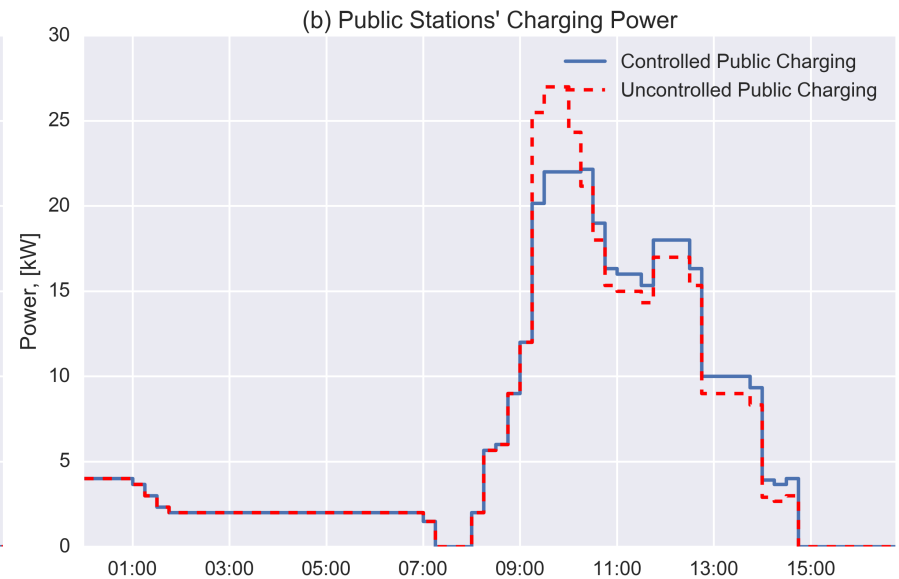
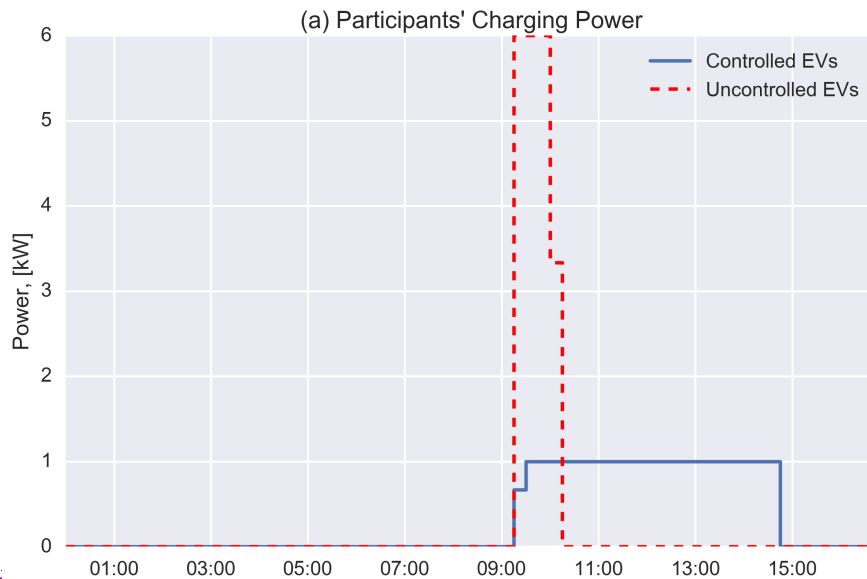
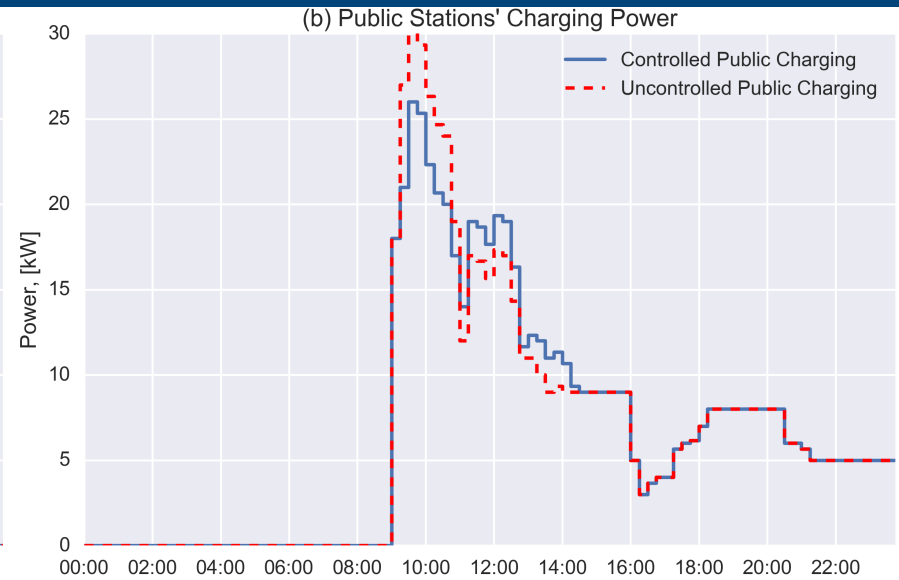
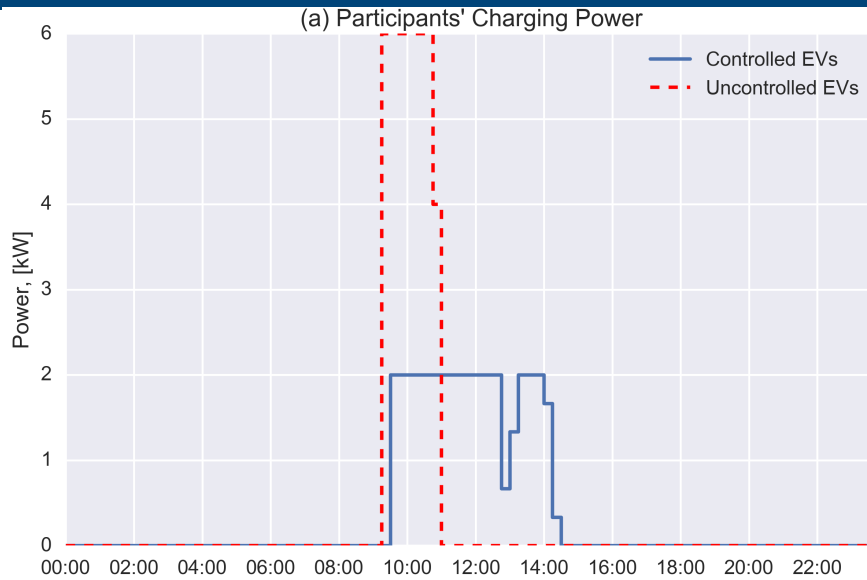
A screenshot of a web browser showing the 'Smart Charging at Alco Park Garage' page from Berkeley Lab. The page has the Berkeley Lab logo and tagline 'Bringing Science Solutions to the World'. The form includes: 'Planned Departure Time: (HH:mm AM/PM)' with dropdowns for '1', '0', and 'PM'; 'How much charge do you need? (kWh or miles)' with a dropdown for '6' and a toggle for 'Or miles'; a checkbox for 'Remember my request info'; a note: 'If your planned departure time changes, please use the same link to complete another smart charging form and we will re-adjust charge schedule.'; and a large green 'Submit' button.

# System Architecture

- LBNL Server:
  - Web-service to: 1) handle smart charging requests; 2) interact with users; 3) data collection; 4) issue control commands
  - Database: storage for all session data, meter data, smart charging requests
  - Smart control optimizer: charging schedule optimization
- Kisensum Server:
  - Communicates with each AICo EVSE via ChargePoint API
  - Sends session info (including user ID) from EVSE to LBNL server
  - Sends optimized charging set points from LBNL server to EVSE

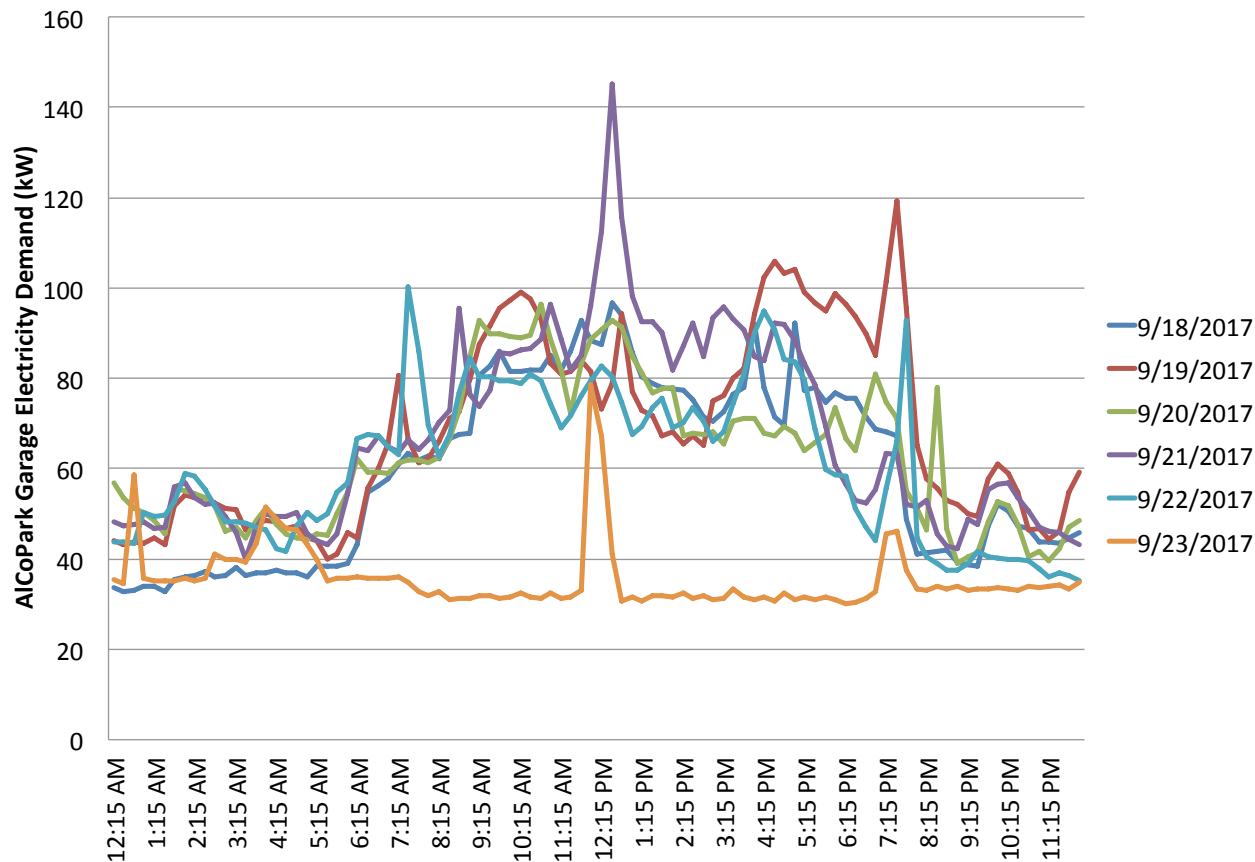


# Public Station Smart Charging Performance

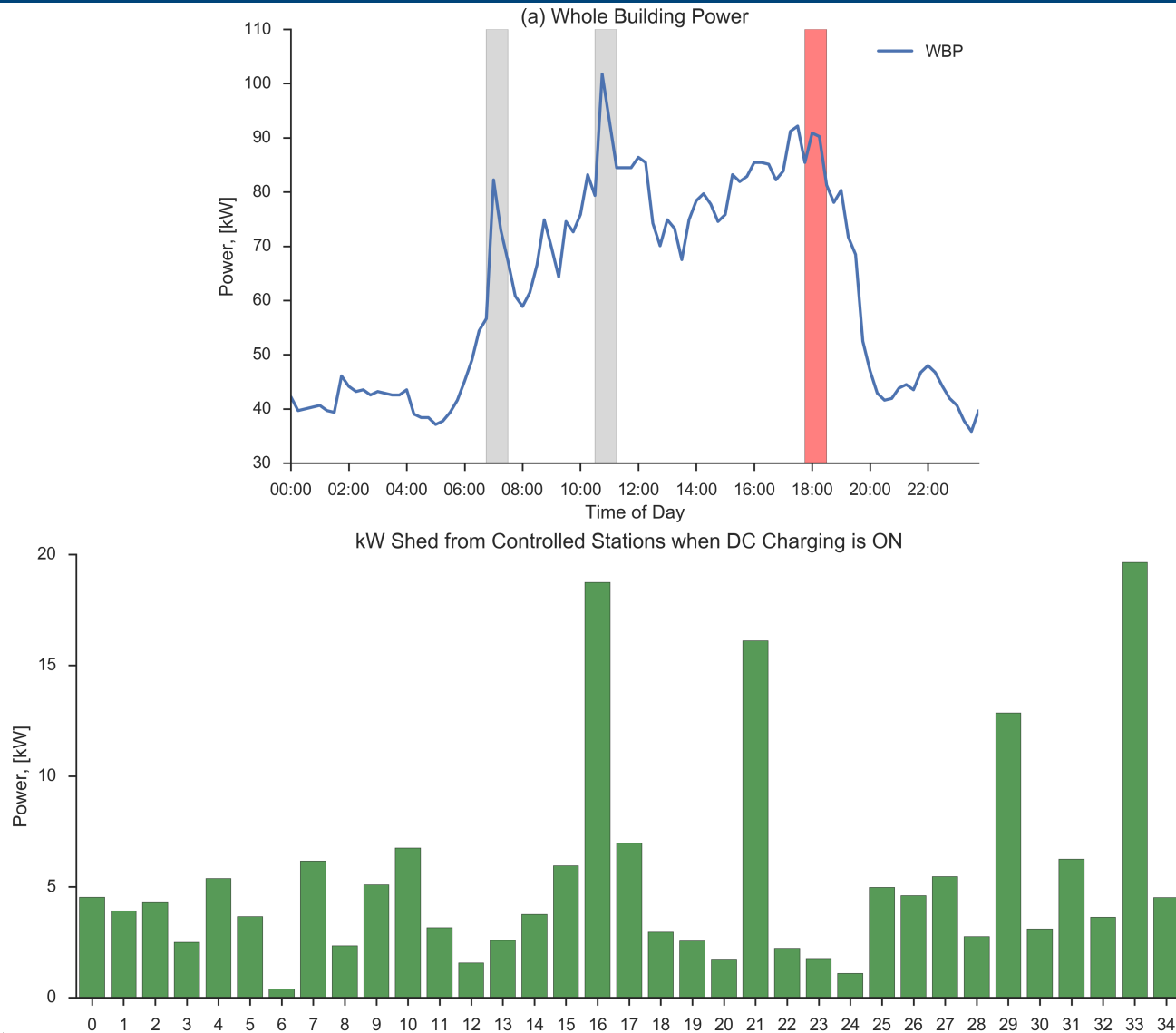


# Fast Charging Benefits and Challenges

- Quick turnaround of fleet vehicles
- But, watch out for demand peaks



# Fleet Level 2 Load Shed with DCFC Sessions



# Next Steps

- Complete data collection and evaluation of Smart Charging at AICoPark Garage
- Submit Final Report

# Thanks!

- Any questions...
  - Doug Black, LBNL, [drblack@lbl.gov](mailto:drblack@lbl.gov)
  - Phillip Kobernick, Alameda County, [phillip.kobernick@acgov.org](mailto:phillip.kobernick@acgov.org)
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